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Involving physicians in IMRT planning by interactive plan navigation

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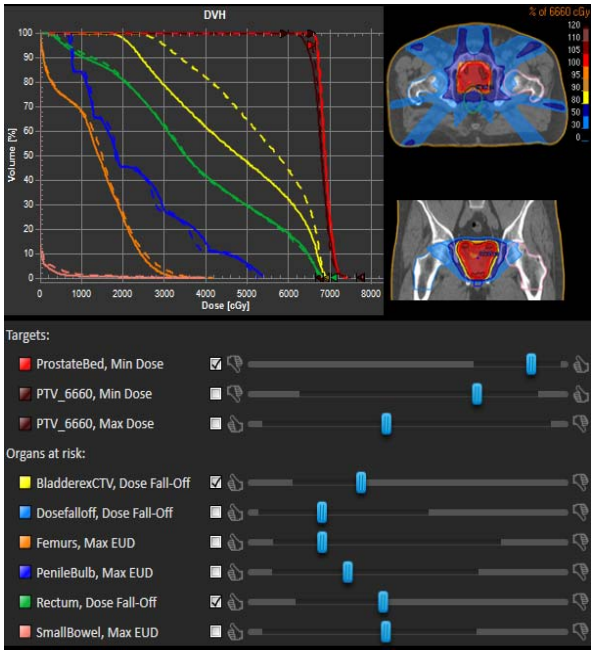
Purpose/Objective: To demonstrate the feasibility of physician driven IMRT planning with a multicriteria optimization (MCO) treatment planning system. The long term objective is to involve physicians at an earlier stage of the treatment planning process in order to increase planning efficiency and allow physicians to more naturally express their clinical intentions.

Materials and Methods: This treatment planning study is based on data of 10 prostate and 12 central nervous system (CNS) cases, previously treated at Massachusetts General Hospital with a clinically approved MCO-IMRT treatment plan, created by dosimetrists. MCO Pareto surfaces were recalculated using identical beam geometries as in the clinical plans. Physicians navigated to their preferred trade-offs and created a deliverable plan (Figure 1). For each patient two plans, the clinically delivered and the physician navigated plan, are evaluated with regard to dosimetric differences and physician preference. Additionally the required navigation times for the physicians were documented.



Results: Overall plans generated by dosimetrists versus physicians were comparative without marked differences. However, evaluation of individual treatment plans demonstrate different focuses of planning target volumes (PTV) and organs at risks (OAR) and between OARs, but not in a consistent way. While most of the evaluated quantities do not show significant deviations, general differences were found for the brainstem (p(D1)=0.029) in CNS, where the physician allowed higher values of D1, and for high dose regions of bladder (p(D1)=0.024, p(V65)=0.003) and rectum (p(D1)=0.005 , p(V65)=0.009), where the physician chose more OAR sparing in exchange for a lower PTV coverage (volume of 98%-isodose: p(V6527)=0.007). The full statistical evaluation and a blinded plan comparison survey of both plans are ongoing. After some introduction to the system, both physicians felt comfortable navigating and exploring the planning possibilities. A learning curve was observable throughout the study: physicians developed strategies and navigation times were reduced (prostate: from 30 to 5 minutes, CNS: case specific variations 15-20 minutes). Recorded physicians statements such as: 'it is great to see the trade-offs' and 'isn't that interesting how much this dose is decreasing for a small increase in the other?' highlight that physicians put great value on being able to navigate their own plans.

Conclusions: Physician driven planning by Pareto surface navigation is feasible. Generally physicians insight into the planning process is of great value. With respect to clinical decisions and planning efficiency the gain appears to be case and anatomical site dependent.

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3D-CRT, VMAT and dose escalation for pancreatic radiotherapy planning

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Purpose/Objective: To compare 3D-CRT and VMAT pancreatic radiotherapy planning, and to assess the feasibility of dose escalation.

Materials and Methods: Fourteen pancreatic 4D-CT datasets were planned using: i) 5-7 field 3D-CRT, prescribing 54Gy in 30 fractions, ii) double arc VMAT, prescribing 54Gy in 30 fractions and iii) double arc VMAT, prescribing 59.4Gy in 33 fractions. For 3D-CRT planning and VMAT planning to 54Gy, at least 98% of the PTV received ≥95% of the prescription dose (PD). For VMAT planning to 59.4Gy, areas of PTV overlap with the stomach and duodenum received ≥80% of the PD, and 95% of the non-overlapped PTV received ≥95% of the PD, as per the SCALOP II protocol. The Wilcoxon signed-rank test was used to compare dosimetric parameters. Spearman's correlations assessed correlations between volumes of PTV-duodenal and PTV-stomach overlap, and dosimetric parameters.

Results: It was necessary to exceed the duodenal V55Gy constraint (usual limit <1cc) in order to achieve coverage in six 3D-CRT plans. There was a strong correlation between the volume of PTV-duodenal overlap and duodenal V55Gy (Spearman's rho: 0.79, p=0.001). Where PTV-duodenal overlap exceeded 20cc, 3D-CRT plans could not be created without exceeding duodenal constraints. All duodenal constraints were met in all VMAT 54Gy and 59.4Gy plans.

It was necessary to exceed the stomach V50Gy constraint (usual limit <16cc) in order to achieve coverage in the five 3D-CRT plans with the largest volumes of PTV-stomach overlap. There was a strong correlation between the volume of PTV-stomach overlap and stomach V50Gy (Spearman's rho: 0.97, p<0.001). Stomach V50Gy was also exceeded in the five corresponding VMAT 54Gy plans. Where PTV-stomach overlap exceeded 15cc, then 3D-CRT and VMAT 54Gy plans could not be created without exceeding stomach constraints. The different coverage requirements, however, allowed all stomach constraints to be met in all but one VMAT 59.4Gy plans. Compared to 3D-CRT plans, VMAT 54Gy plans resulted in significant reductions in small bowel V50Gy, left and right kidney V20Gy, mean liver dose and duodenal V50Gy (Table 1). There was a small but statistically significant increase in PTV mean dose with VMAT 54Gy compared to 3D-CRT (Table 1) and there was, unsurprisingly, a significant increase in PTV mean dose when prescribing VMAT 59.4Gy compared to VMAT 54Gy (VMAT 59.4Gy vs VMAT 54Gy: 57.7Gy vs 54.1Gy, p<0.001 (median values)).

Table 1. Dosimetric outcomes (median values shown)

	Constraint (where applicable)	**3D-CRT 54Gy**	**VMAT 54Gy**	Dosimetric comparison (where statistically significant)
PTV mean dose (Gy)	-	53.9	54.1*	**VMAT 54Gy > 3D-CRT, p=0.041*
Small bowel Dmax to 0.1cc (Gy)	<58Gy	54.5	54.7	
Small bowel V50Gy (cc)	-	8.3	5.9*	**VMAT 54Gy < 3D-CRT, p=0.034*
Left kidney V20Gy (%)	<45%	12.1	2.1*	**VMAT 54Gy < 3D-CRT, p=0.017*
Right kidney V20Gy (%)	<45%	20.9	2.1*	**VMAT 54Gy < 3D-CRT, p=0.010*
Liver V30Gy (%)	<30%	1.9	2.2	
Mean liver dose (Gy)	-	6.9	6.4*	**VMAT 54Gy < 3D-CRT, p=0.028*
Spinal cord Dmax (Gy)	<45Gy	23.8	27.0	
Stomach Dmax to 0.1cc (Gy)	<58Gy	54.5	55.1	
Stomach V50Gy (cc)	<16cc	15.2	13.5	
Duodenal Dmax to 0.1cc (Gy)	<58Gy	54.6	55.1	
Duodenal V55Gy (cc)	<1cc	0.0	0.2	
Duodenal V50Gy (cc)	-	20.1	17.1*	**VMAT 54Gy < 3D-CRT, p=0.033*

Conclusions: VMAT improved dose sculpting, thereby providing dosimetric advantages in several normal tissues and a potential solution in cases where constraints were not met using 3D-CRT. Volumes of PTV-duodenal and PTV-stomach overlap may be useful indicators as to the feasibility of 3D-CRT planning. Because of lower coverage requirements in areas of PTV overlap, escalation to 59.4Gy using VMAT was feasible in most cases, facilitating higher mean PTV doses while still respecting normal tissue constraints.

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Use of surgical clips for online setup verification in radiotherapy of breast cancer: a comparison with skin markers

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Purpose/Objective: In 2008 we developed an off line set-up verification protocol for breast cancer patients with external skin markers [Van der Salm Radiother. Oncol. **90**] using MV imaging, followed by online set-up correction in 2012 using KV imaging. However, we noticed an increase in skin reaction localized to the skin markers. Therefore we evaluated the feasibility of online setup correction with surgical clips evaluating dose coverage of breast and boost area.

Materials and Methods: In 34 breast cancer patients an online set-up correction was performed using the external skin marker technique. Set-up correction was performed based on the match between a pair of orthogonal KV images with DRRs of the planning CT scan, based upon contoured skin markers and anatomical landmarks (eg. thoracic wall). In retrospect, all images were re-matched with DRRs with contoured surgical clips in the post-operative breast. In addition, for each patient 3 Cone Beam CTs (CBCT) were available. At first we investigated the migration of the surgical clips for set-up verification by measuring the inter-clip distances at the beginning, middle and end of treatment on a CBCT with the planning CT as a reference. We then compared the setup as determined from the clips with that from our skin markers in 5 fractions for each patient (total 170 fractions). Finally, we looked at the breast CTV coverage by recalculating the dose on the online setup corrected CBCT (including a re-contoured breast and boost CTV) with the patient setup according to both setup techniques. This coverage was compared with that of the treatment plan.

Results: Almost all types of surgical clips could be well visualized: 4.7 (sd 0.7 range 3-6) clips per patient were available for analysis. Analysis of the interclip distance showed that the clip to center-of-mass (COM) distance decreased on average by 2 (sd 1) mm (absolute distance clip-COM: 15(sd 8) mm). Differences between clip and marker setup were generally small (avg<0.3mm in all directions). The reconstructed dose distributions on the CBCT showed that the coverage (95% isodose) of the breast was 99% in the treatment plan, and remained 99% for the skin marker as well as for the surgical clip technique. Also the boost area coverage remained at 99% for both techniques and the treatment plan. Some differences in rotation (max 2 degr.) setup were observed between clip and skin marker technique, but in light of conservation of coverage those differences were indicated as not clinically relevant.

Conclusions: The use of surgical clips for online position verification/correction using orthogonal-pair KV imaging results in as good target coverage as the use of skin markers, even though there is some migration of the clips. The use of surgical clips provides a simpler solution for position verification as compared to our skin markers, without the disadvantage of local increase of skin dose.

Electronic Poster: Clinical track: Health economics

EP-1324

Improved access to radiotherapy for lung cancer impacts utilisation rates and waiting times

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